

**THE EFFECTS OF TEMPERATURE AND MOISTURE
ON THE EGGS OF EPILACHNA CORRUPTA MUL-
SANT (COCCINELLIDAE, COLEOPTERA).¹**

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It has been shown (Sweetman and Fernald, 1930) that the egg stage of the Mexican bean beetle is a very critical one, as embryonic development is greatly influenced by temperature and moisture. However, the complete limitations of temperature and moisture were not established in that paper. The purpose of this study was to determine the effects of temperature and moisture on the egg stage of the bean beetle throughout the ranges for these factors.

REVIEW OF LITERATURE

Very few workers have studied the effects of temperature and moisture on the egg stage of the bean beetle in controlled environments. The most complete paper on this subject is that of Sweetman and Fernald (1930). These workers did not expose the eggs to many temperature conditions below 22° C. and relative humidity conditions below 60 per cent; thus were unable to establish definite zonal limits for low temperature and low humidity. Later Marcovitch and Stanley (1930) published some data on the effects of these factors on the incubation of the eggs. They did not measure the moisture conditions around the eggs in their experiments, but apparently the humidity was high. Their data are too limited from which to draw additional conclusions to those of Sweetman and Fernald.

METHODS USED

The temperature was controlled with electrical heating units operated with thermostats. The relative humidity was maintained by the use of saturated salt solutions in closed pint fruit jars, and measured with a dew-point apparatus (Marvin, 1915).

The pieces of leaves containing the eggs were fastened to cardboard strips with shellac. This was done to avoid the difficulty,

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reported by Sweetman and Fernald, produced by the drying and curling of the leaf tissues which injured some of the eggs and prevented the emergence of some of the larvae. The shellac dried quickly and no injury to the eggs was apparent. The strips of cardboard with the eggs were placed in open vials which were suspended in the humidity jars.

EXPERIMENTAL RESULTS

A series of temperatures ranging from 7° to 32° C. at intervals of 5° , except near the maximum and minimum effective temperatures, where the intervals were smaller, were used. The eggs were exposed to a wide spread of humidities at the different temperatures.

A constant temperature of 7° and 12° C. was below the minimum effective temperature regardless of humidity conditions (Table I). These eggs were exposed for about three weeks, then removed to room temperature (22°) with the humidity jars, but no development occurred. A microscopical examination at this time showed that very little, if any, development had taken place before death in the low temperature condition.

About fifty larvae from two lots of eggs were exposed shortly after hatching to a temperature of 7° C. with about 70 per cent relative humidity, but all died within a few days after hatching. An ample supply of suitable food was furnished to the larvae.

A variable temperature of 13.5° to 15° C. did not hatch any eggs with low humidity, an occasional egg with high humidity, and only 16 per cent. with 77 per cent. humidity. About 10 per cent. of the embryos were well-developed in the dry condition. Apparently the average temperature was near 15° as the results are very similar to those obtained in constant temperature conditions at 15° .

A temperature of 15° C. was unsuitable with low humidity, but 12 per cent. of the eggs hatched in the 95 per cent. moisture condition. Probably a much better hatch would have occurred in a 75 per cent. humidity environment with this temperature.

An exposure of the eggs to a low temperature of 12° C. for two separate twelve-hour periods, and to 17° the remainder of the incubation period, with 77 per cent. humidity, produced a 49 per cent. hatch. This shows that short exposures to a temperature slightly below the minimum effective temperature, with favorable humidity, may permit good hatching of the eggs.

A constant temperature of 17° C. was very favorable with high moisture conditions of 74 to 94 per cent., unfavorable with 37 per cent., and unsuitable with 26 per cent. relative humidity. The eggs in the moist atmosphere were covered with a fungus growth, that developed on the bean leaf tissue. Apparently the eggs were not attacked by the fungus. The length of the incubation period was approximately the same in all conditions where eggs hatched.

Good hatches of the eggs resulted in 22° C. conditions with humidities above 75 per cent. The leaf tissues were attacked by a fungus without perceptibly injuring the eggs in the moist condition. Low humidities were very unfavorable as only a few eggs hatched in 20 and 32 per cent. conditions. Well-developed embryos were in most of the remaining eggs in the latter condition, but were unable to emerge. Many larvae died with their heads protruding from the egg coverings, either being too weak or the egg coverings too dry and stiff to allow them to emerge from the egg. The length of the incubation period was about 12 per cent. less in high than in low humidities.

The effects of a temperature of 27° C. with different humidities is very evident. A low humidity of 25 per cent. is still unsuitable, while 58 per cent. permitted a little over half of the embryos to develop and emerge. Humidities of 76 and 81 per cent. gave about the same results as at 22° , but higher moisture environments reduced the percentage of hatch. This shows that 27° is less favorable than 22° , but still within the zone of economic importance.

A temperature of 30° C. is unfavorable for embryonic development. None of the eggs hatched in 20 per cent. moisture conditions, and only 2 per cent. in the 57 per cent. condition. The most favorable humidity, 76 per cent., yielded 27 per cent. of larvae, thus showing that 30° is very unfavorable and is near the maximum effective temperature. A smaller hatch occurred in the wetter conditions, with none of the eggs hatching in the saturation environment. The shorter incubation period occurred in the 76 per cent. relative humidity chamber.

The embryos failed to develop in the 32° C. conditions regardless of the humidity content of the environment. When 32° was alternated with 22° the percentage emerging was intermediate to the number obtained in the constant conditions.

SUMMARY

A temperature of 7° C. was entirely unsuitable for embryonic or young larval development.

A temperature of 12° was unsuitable for incubation of the eggs in all moisture conditions. The embryos were dead at the end of three weeks. Short exposures for twelve hours at a time did not prevent hatching of about half of the eggs when exposed to 17° during the remainder of the incubation period.

A temperature of 15° was very unfavorable, but a few eggs hatched in the wet environment. The incubation period required 23 days. An exposure to a variable temperature of 13.5° to 15° gave about the same results as in 15° continuously.

A temperature of 17° was favorable for good hatching in 74 and 94 per cent. moisture environments, but the hatch was greatly reduced in 37 per cent., and none hatched in the 26 per cent. condition. The incubation period required 10 to 11 days.

A temperature of 22° is near the optimum temperature with all humidities. This is the only temperature in which some of the eggs hatched in all humidities from 20 per cent. or above. The number of eggs hatching was low in the 20 and 32 per cent. conditions, while good hatches occurred in the moist environments. The incubation period required from 6.5 to 8 days.

A temperature of 27° was favorable with high humidities and unfavorable with dry conditions. The best hatches occurred with 76 and 81 per cent. moisture environments. The incubation period required 5 to 6 days.

A temperature of 30° was unfavorable; about one-fourth of the eggs hatching with 76 per cent. humidity, and none hatching with 20 and 100 per cent. moisture conditions. The incubation period required from 5 to $5\frac{1}{2}$ days.

A constant temperature of 32° was very unfavorable in all humidity conditions. When alternated with 22° , with high and low humidities, the results were intermediate between those obtained in 32° and 22° constant environments.

CONCLUSIONS

The eggs of the Mexican bean beetle hatch best in an environment of about 22° C. and 75 per cent. relative humidity. The minimum effective temperature is near 13.5° and the maximum effective temperature near 30° . The best humidity is near 75 to 80 per cent. Low humidities below about 55 per cent. are very

unfavorable in all temperature conditions. High humidities of 95 to 100 per cent. are unfavorable except near the optimum temperature.

LITERATURE CITED

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Table I. The effects of temperature and moisture on the eggs of the Mexican bean beetle.

Relative humidity	Total number of eggs	Total number hatched	Per cent. hatched	Days to hatch
Temperature 7° C.				
39	71	0	0	—
77	118	0	0	—
95	59	0	0	—
Temperature 12° C.				
37	145	0	0	—
77	154	0	0	—
98	148	0	0	—
Temperature 13.5° C. to 15° C.				
37	185	0	0	—
77	323	51	15.8	23.5
98	191	2	1.0	26.0
Temperature 15° C.				
28	355	0	0	—
38	276	0	0	—
95	146	18	12.3	23.0

Temperature				
12° C. twice for 12 hrs.; 17° C. rest of time				
77	301	147	48.8	13.1
Temperature 17° C.				
26	394	0	0	—
37	212	67	31.6	10.9
74	232	193	83.2	10.7
94	146	125	85.6	10.7
Temperature 22° C.				
20	324	2	0.6	7.8
32	150	11	7.2	7.9
76	129	93	72.0	7.4
78	126	99	78.6	6.6
81	109	89	81.6	6.7
84	147	97	66.0	6.6
97	183	164	89.6	6.7
Temperature 27° C.				
25	97	0	0	—
58	262	148	56.5	5.9
76	250	178	71.2	5.9
81	351	251	71.5	5.6
97	192	123	64.1	5.5
100	213	149	69.9	5.0
Temperature 30° C.				
20	130	0	0	—
57	337	6	1.8	5.5
76	231	63	27.3	5.2
97	349	78	22.3	5.4
100	204	0	0	—
Temperature 32° C.				
17	46	0	0	—
76	41	0	0	—
97	62	0	0	—
100	337	0	0	—
Alternating Temperature				
8 hrs. at 32° C. — 16 hrs. at 22° C.				
17-31	114	0	0	—
76	109	71	65.1	7
97	114	67	58.8	7